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Reprinted from The Journal of the American Medical Association
Jan. 27, 1912, Vol. LVIII, pp. 265-268

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BLOOD-PRESSURE OBSERVATIONS ON PATIENTS WITH RELAXED ABDOMINAL MUSCULATURE *

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Systolic blood-pressure readings taken while the individual observed is standing vary more or less from readings obtained in the recumbent posture. Edgren, Cook and Briggs, Gärtner, Goldwater, Hill, and Brush and Fayerweather, quoted by Janeway,[1] found the pressure 5 to 15 mm. Hg lower in the horizontal position, while Hensen, Friedmann, Shapiro and von Recklinghausen, quoted by the same author, found a fall of 10 to 15 mm. Hg on standing. Janeway[1] gives the increased ratio to the standing position and Michell observed the variation in the same direction. Evidence relative to the physical condition of the individuals examined is, in most cases, wanting, though Michell's[2] examination of over 1,600 Cambridge athletes is suggestive and serves to direct inquiry toward the physical condition as a cause for the difference of opinion. The numerous factors concerned in the production and maintenance of the blood-pressure and the various influences, both mental and physical, which may alter it, make it difficult to correlate the results obtained by different observers. In a healthy individual variations in the readings occur at different times during the day, bearing some relation to the taking of food, mental states, amount and kind of

* Read before the San Francisco County Medical Society, Nov. 14, 1911.

1. Janeway, Theodore A.: The Clinical Study of Blood-Pressure, 1904.

2. Quoted by Sir C. Allbutt in Allbutt's System of Medicine, Ed. 2, vi, 201.

work done, and the ability to withstand fatigue and to recuperate therefrom.

The observations on which this brief report is based were undertaken for the purpose of determining to what extent postural variations in blood-pressure were present in cases of enteroptosis with relaxed abdominal musculature. It had been observed that in these patients the systolic pressure usually fell from 10 to 25 mm. Hg on standing after lying; that the severity of the symptoms seemed to bear some relation to the amount of systolic fall, being more marked with a low reading, and that on the days when these individuals were feeling their best, the reading taken while standing remained close to the one obtained in the recumbent posture.

That the results of the examinations might be as accurate as the means at hand would permit, in the beginning both the Erlanger sphygmomanometer and the Faught blood-pressure apparatus were used, the auscultatory method of Korotkoff[3] being employed with the latter, and the diastolic pressure being read at the fourth phase. Later, as there was little variation in the results obtained by the two methods, we adhered to the latter as being simpler and occupying less time. In some patients whose arteries possess little tone and whose pulse-pressure is low, it is difficult to get an accurate diastolic record; we therefore omitted them from the charts as being useless in computing the averages. The figures, then, representing the pulse-pressure in Table 3 may be considered as being a trifle higher than the true conditions warrant. Determinations in the horizontal position were made repeatedly until the pressure became constant. The standing readings were taken immediately after the patient rose from the table.

HEALTHY INDIVIDUALS LEADING MODERATELY SEDENTARY LIVES

In Table 1 it will be observed that while the systolic pressure is well maintained during change of position it did not rise on standing as in the athletes examined by Michell. This is due to the fact that these subjects, though healthy, were not in their best physical condition. Since the degree of muscular tone bears an important relation to the rapidity with which the effect of gravity

3. Gittings, J. C.: Auscultatory Blood-Pressure Determination, Arch. Int. Med., August, 1910, vi, 196.

in the standing position is overcome, in well-trained men immediate adjustment of the circulation is effected in the changed position.

The systolic determinations, however, present only one side of the question and in order to determine to what extent the blood-propelling mechanism is efficient, consideration must also be taken of the diastolic pressure, pulse-pressure and pulse-rate. Erlanger and Hooker[4] found that the diastolic pressure rose, the pulse-pressure decreased and the pulse-rate rose accordingly on standing after lying. This is in accord with the findings given in Table 1, and with the systolic pressure there given

TABLE 1.—TYPE CASES OF NORMAL INDIVIDUALS LEADING MODERATELY SEDENTARY LIVES

Subject	Time	Position	Max.	Min.	Pulse-Pressure	Pulse-Rate
1	3 :12	Reclining.	120	70	50	84
1	3 :20	Standing.	120	80	40	84
2	3 :00	Reclining.	120	75	45	80
2	3 :20	Standing.	118	80	38	84
3	3 :00	Reclining.	108	78	30	84
3	3 :10	Standing.	106	88	18	88
4	2 :04	Reclining.	124	80	44	71
4	2 :12	Standing.	120	90	30	74
5	2 :19	Reclining.	120	72	48	82
5	2 :32	Standing.	115	74	36	84

Average of twenty cases:

Fall of the systolic..... 3.1 mm.
Rise of the diastolic..... 7.6 mm.
Fall in pulse-pressure..... 9.8 mm.
Increase in pulse-rate..... 3.0 mm.

probably represents the blood-pressure conditions present in healthy individuals not undergoing muscular training.

PERSONS WITH RELAXED ABDOMINAL MUSCULATURE

In the subjects with marked abdominal muscle relaxation (Table 2), the systolic pressure always fell from 10 to 25 mm. Hg on standing after lying. The diastolic, instead of rising, either remained stationary or fell and the pulse-pressure decreased as in the normal. But this decrease in pulse-pressure was caused, not by a diastolic rise as in the normal, but by a systolic fall. It is quite

4. Erlanger and Hooker: An Experimental Study of Blood-Pressure and Pulse-Pressure in Man, Johns Hopkins Hosp. Rep., xii, 236.

a different matter if the decrease in the pulse-pressure is brought about by a fall in the systolic rather than by a diastolic rise. Pulse-pressure may be increased, decreased or unchanged, according as the systolic and diastolic pressure, separate, come together, or move to the same extent in the same direction.

In this group, the noticeable increase in the pulse-rate, while undoubtedly effectual in preventing the extreme results of change in position, was yet inadequate to overcome entirely the effect of gravity.

The question now arises, is the fall in the blood-pressure on standing due to the relaxed abdominal musculature, or is it due to other factors?

If the cases of abdominal relaxation with ptosis in which symptoms were present were considered alone it might be concluded that the relaxation bore a definite causative relationship to the fall in blood-pressure. Indeed, there is an abundance of anatomic and physiologic evidence which might be used in support of such a contention. The diaphragm has long been considered as a most important adjunct to the circulation. Its chief use is in the standing position when, acting in opposition to the abdominal muscles, it forms the so-called respiratory pump and assists in lifting the blood from the abdominal veins to the right heart. In the recumbent posture the need for the respiratory pump no longer exists, the diaphragm moves slightly or not at all, the respirations become thoracic in character and the circulation of the blood is maintained by the action of the heart and vasomotor system.

From laboratory experiments Emerson[5] concluded that:

> In the animals tested it is normal to exhibit a pressure in the free abdominal cavity which is above atmospheric pressure; that whatever diminishes or abolishes the tone of the diaphragm and abdominal muscles causes a fall in the positive abdominal pressure and that whatever increases the tone of the diaphragm and abdominal muscles will cause a rise in the intra-abdominal pressure above normal.

Arthur Keith[6] says:

> In man the pressure exerted on the abdominal contents by the abdominal muscles, maintaining one viscus against another may be estimated at from 6 to 12 mm. Hg. The mus-

5. Emerson, Haven: Arch. Int. Med., June, 1911, p. 754.
6. Keith, Arthur: Allbutt's System of Medicine, Ed. 2, iii, 867.

cles of the abdominal wall are active opponents of the diaphragm, and when the abdominal muscles are paralyzed the diaphragm is thrown out of action just as completely as if it were intrinsic paralysis. But directly a support is applied to the lower part of the abdomen, the epigastrium fills out and by the aid of the radioscopic screen the diaphragm is seen to be pressed up, assuming an expiratory position, and immediately eases the movements of respiration, slows and improves the heart-beat and raises the arterial pressure.

Again Emerson[7] says:

Any marked loss of abdominal tone is recognized clinically as a contributing cause of venous stagnation in the abdominal

TABLE 2.—TYPE CASES OF RELAXATION OF THE ABDOMINAL WALL

Subject	Time	Position	Max.	Min.	Pulse-Pressure	Pulse-Rate
1	2:00	Reclining.	118	85	33	76
1	2:15	Standing.	92	72	20	92
2	2:46	Reclining.	124	85	39	84
2	2:55	Standing.	104	80	24	92
3	2:30	Reclining.	130	95	35	84
3	2:40	Standing.	110	85	25	104
4	3:33	Reclining.	110	78	32	70
4	3:45	Standing.	100	70	30	90
5	2:10	Reclining.	120	95	25	84
5	5:20	Standing.	110	95	15	90

Average of twenty-five cases:

Fall of the systolic..... 19.5 mm.
Fall of the diastolic..... 6.1 mm.
Fall of pulse-pressure..... 8.0 mm.
Increase in pulse-rate..... 15.0 mm.

viscera, and this means a delayed or insufficient venous return to the right heart, a diminished output and a fall in the arterial pressure, or a pressure maintained only at the expense of greater cardiac action. In general, it may be stated that a lack of normal abdominal pressure is a contributing cause of general arterial low pressure.

But there are many patients with extreme ptosis and abdominal walls absolutely atonic who suffer no symptoms referable to the disorder itself or to its effect on the circulation. It is a matter of common observation that visceral ptosis of marked degree may exist without producing a single subjective symptom. True, in these cases it is usual to find a greater systolic fall on standing

7. Emerson, Haven: Arch. Int. Med., June, 1911, p. 754.

than in the normal. But the diastolic is well maintained, and so long as it is, the effect of gravity is compensated and the circulatory symptoms are absent.

Interesting in this connection is the effect of arterial hypertension. Table 3 shows four cases of extreme abdominal muscle relaxation complicated with chronic nephritis. This condition was sufficient to maintain both systolic and diastolic pressures, during change of position and in some cases even to the extent observed in athletes. Injurious as the chronic nephritis may have been in other directions, it certainly served to counteract the effect of the relaxation, for the cases observed were free from subjective symptoms.

It is generally agreed that the larger part of the vasomotor regulating function resides in the splanchnic circulation. Of all the parts of the vascular system, the abdominal vessels enervated by the splanchnic nerves have by far the greatest effect on the general blood-pressure. Such an effect is seen in section of the splanchnic nerves. On the other hand, constriction of this area causes the blood-pressure to rise.

The splanchnic circulation is maintained by two main factors: first, the vasomotor mechanism, and second, the action of the diaphragm, the so-called respiratory pump. The diaphragm depends for its normal action on the integrity of the abdominal muscles. If they are deficient in tone, the diaphragm remains in the inspiratory phase with a consequent loss to the circulation of the respiratory pump. Thus the whole burden of maintaining the splanchnic circulation in the standing position falls on the vasomotor mechanism and it is not until this fatigues that symptoms appear.

The association of splanchnoptosis with relaxed abdominal wall has long been recognized and the accompanying symptoms have usually been ascribed to stretching or torsion of the visceral supports or to intestinal angulation. That the lowered position of the hollow viscera is detrimental to their function seems unlikely, for an otherwise healthy intestine should be able to propel its contents with equal facility in any direction. It has been seen that visceroptosis of marked degree may exist without producing a single subjective symptom. Where, however, symptoms do arise, they are of two types: neuropathic, as syncope, vertigo, insomnia, etc., and gastro-intestinal, as indigestion, meteorism, consti-

pation and mucous colitis. A discussion of the former group only is within the scope of this paper.

In relaxation of the abdominal musculature we find a decreased intra-abdominal pressure and a decreased power of aspiration of the heart and diaphragm which tend to permit stagnation of the blood in the visceral veins. If, then, the vasomotor system becomes incompetent the amount of blood returning to the right heart per unit of time is less than normal, the systolic output

TABLE 3.—RELAXED MUSCULATURE COMPLICATED WITH CHRONIC NEPHRITIS

Subject	Time	Position	Max.	Min.	Pulse-Pressure	Pulse-Rate
1	2:15	Reclining.	150	95	55	72
1	2:25	Standing.	158	110	48	76
2	11:05	Reclining.	165	110	55	68
2	11:15	Standing.	165	110	55	74
3	11:30	Reclining.	175	90	85	64
3	11:45	Standing.	165	90	75	66
4	12:14	Reclining.	180	95	90	78
4	12:25	Standing.	174	110	64	90

Average fall of the systolic..... 2.00 mm.
Average increase of the diastolic.. 7.50 mm.
Average fall of the pulse-pressure 10.75 mm.
Average increase in the pulse-rate 6.00 mm.

is diminished, and we have a degree of chronic anemia of the tissues. This *must* have its effect on the cerebral circulation, to changes in which some of the symptoms can be ascribed.

Leonard Hill[8] tells us:

> The intracranial pressure is purely circulatory in origin and may vary largely with the changes in the general circulatory pressure. In all physiologic conditions a rise of the arterial pressure accelerates the flow through the brain, a fall slackens it.

Erlanger and Hooker, quoted from Hirschfelder,[9] say:

> When normal men were supported and kept motionless in the vertical posture the blood-pressure fell (e. g., maximum fell from 120 mm. to 103 mm., minimum from 92.5 mm. to 86 mm., pulse-pressure from 26.7 mm. to 17 mm.), and in one

8. Hill, Leonard: Pathology of the Cerebral Circulation, in Allbutt's System of Medicine, Ed. 2, viii.

9. Hirschfelder, Arthur: Diseases of the Heart and Aorta, 1910, p. 599.

case there was "pallor, yawning, a feeling of warmth, faintness, nausea," and threatened syncope. These are the symptoms of cerebral anemia common in patients with enteroptosis.

VERTIGO IN VISCEROPTOSIS

The dizziness frequently present in cases of visceroptosis is often attributed to the movable kidney, discovered on examination. In the text-book dizziness is given as one of the prominent symptoms of nephroptosis. But where dizziness is present, if the blood-pressure is taken, it will be found to show both a systolic and a diastolic fall on standing after lying.

In order to understand how the vertigo may develop in these cases it is necessary to review briefly the mechanism of space orientation. The sensations which originate in the semicircular canals probably give the fundamental perception of equilibrium. This perception is conducted by the vestibular nerve to, and prepared in, the cerebellum, but does not become a conscious sensation until it reaches the cerebrum by way of radiating fibers passing through the cerebellar peduncle and red nucleus. Circulatory conditions which cause abnormal excitation of the semicircular canals, such as cardiac diseases, arteriosclerosis, anemias, give us a contradiction between the perception from the semicircular canals and the position of the body as elaborated by the cerebrum. Thus in these cases with unstable circulation the excitation of the semicircular canals may be out of proportion to the stimuli received and consequently we have a false conception of space.

INSOMNIA IN VISCEROPTOSIS

Insomnia, present in a large percentage of these cases, we believe to be due to the fact that in the recumbent posture the blood-pressure is increased over what it is in the vertical position. This brings about the condition of the normal man when standing, one of accelerated cerebral circulation. In order to maintain the circulation in the erect position the vasomotor mechanism is tuned to its utmost capacity and adjustment in the horizontal posture is not so readily accomplished. Consequently there is an accelerated cerebral circulation for a considerable time after lying down and the onset of sleep is retarded. We have been able to produce sleep in many of these cases by raising the foot of the bed a

few inches, thus increasing the pressure in the superior vena cava and thereby impeding the cerebral circulation.

TREATMENT

The treatment of these cases has been varied and unsatisfactory. Efforts with rest, supports, diets, overfeeding, exercise and surgery have too often met with discouraging results. The benefits derived from rest in bed are due mainly to the fact that in the horizontal posture the piston-like action of the diaphragm is not required either for respiration or circulation. The circulation and nutrition are improved, the patient gains in weight and has a feeling of general well-being. But as soon as the vertical position is assumed, the strain is again put on the splanchnic circulation and when this becomes fatigued the symptoms recur.

The reason that the abdominal support does not wholly relieve the symptoms is that it accomplishes only part of the work of the normal muscles. It holds the abdominal wall in a position of muscular contraction and the diaphragm in expiratory phase, for, being more or less of a fixed support, it does not relax as the normal muscles in the inspiratory phase; thus the diaphragm is unable to make its complete excursion and only part of the effect of its suction action is obtained.

The subjects of diet, exercise and surgical treatment have recently been brought to notice and will be omitted here.

If the splanchnic circulation can be made to compensate, the symptoms of cerebral anemia will disappear, but this will, however, have little or no effect on this great atony which is after all the fundamental problem. To relieve the symptoms by causing the splanchnic circulation to compensate is no simple matter; to quote the words of Mackenzie:[10]

> The question of low pressure and its treatment is an extremely puzzling one. Here again we meet the confident assertion in hypotonic conditions, give cardiac stimulants or vasoconstrictors. The matter is, however, far more complicated and I am only dimly groping after the true principles of treatment in these cases.

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10. Mackenzie, J.: Diseases of the Heart.

CONCLUSIONS

1. It may be normal to have a slight systolic fall on standing after lying in healthy individuals who are not undergoing active muscular training.

2. Patients with relaxed abdominal musculature and enteroptosis, not showing subjective symptoms, will be found to have at least the diastolic sustained in change of position and it may be assumed that the vasomotor mechanism is competent.

3. Patients with relaxed abdominal musculature and enteroptosis with circulatory symptoms will show both a systolic and a diastolic fall on standing after lying.

4. The neuropathic symptoms found in these cases are not due to the malposition of the viscera nor can they be placed among the neuroses. They are entirely dependent on the cerebral anemia.

5. The circulatory changes, while the cause of the symptoms, are not the primary etiologic factors, but are second to the great muscular atony, the cause of which is yet unknown.

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